NSTS - 08397

nd #64237

STS-28 NATIONAL SPACE TRANSPORTATION SYSTEM MISSION REPORT

September 1989

NASA
National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center
Houston, Texas

NSTS-08397

STS-28

NATIONAL SPACE TRANSPORTATION SYSTEM

MISSION REPORT

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September 1989

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INTRODUCTION

The STS-28 National Space Transportation System (STS) Mission Report contains a summary of the vehicle subsystem activities on this thirtieth flight of the Space Shuttle and eighth flight of the OV-102 (Columbia) Orbiter. In addition to the Columbia, the flight vehicle consisted of an External Tank (ET) (designated as ET-31/LWT-24), three Space Shuttle main engines (SSME's) (serial no. 2019, 2022, and 2028), and two Solid Rocket Boosters (SRB's) (designated as BI-028). The STS-28 mission was a classified Department of Defense mission, and as such, the classified portions of the mission are not presented in this report. The sequence of events for this mission is shown in Table I. The report also summarizes the significant problems that occurred in the Orbiter subsystems during the STS-28 mission. The problem tracking list is presented in Table II. Each of the Orbiter problems is also cited in the subsystem discussion within the body of this report.

The crew for this thirtieth flight of the Space Shuttle were Brewster H. Shaw, Jr., Col., USAF, Commander; Richard N. Richards, Cdr., USN, Pilot; James C. Adamson, Lt. Col., USA, Mission Specialist 1; David C. Leestma, Cdr., USN, Mission Specialist 2; and Mark N. Brown, Lt.Col., USAF, Mission Specialist 3.

MISSION SUMMARY

The launch countdown was held at the T-9 minute built-in hold longer than planned when the network signal processor (NSP) had a frame synchronization error and a master memory unit (MMU) area 1 read problem occurred during the transition from OPS 9 to OPS 1. After a computer update to retrieve OPS 1 from area 2 of the MMU, a successful transition was made.

During the prelaunch abort command verification test, both of the abort advisory B lamps failed to illuminate. As a result of this condition, a prelaunch test was required to ensure the proper operation of the rest of the annunciator control assembly (ACA). The problem was isolated to either channel 31 of the ACA or the B bulbs, and the failure did not impact mission operations.

A problem occurred during prelaunch activities when one of the nose gear weight-on-wheels proximity sensors began indicating weight on the nose gear. This condition cleared after orbital insertion, but returned later in the flight. This condition causes a weight-on-wheels dilemma at main gear touchdown, and this affects flight control system gains and prevents automatic engagement of nose wheel steering during postlanding rollout. The crew was instructed to follow the standard backup procedure of depressing either the ET SEP INIT or SRB SEP pushbutton to engage nose wheel steering at nose gear touchdown. The weight-on-wheels dilemma occurred at landing. The nose wheel steering was manually enabled by depressing the SRB SEP pushbutton, and the subsystem operated properly.

The STS-28 mission was successfully launched from Launch Complex 39B at 220:12:37:00.012 G.m.t. (07:37:00:012 c.d.t.) on August 8, 1989. The launch phase, which was on an inclination of 57 degrees, was satisfactory in all respects. All Orbiter subsystems operated nominally.

The SSME and solid rocket motor (SRM) ignitions occurred as expected. First stage ascent performance was nominal, but lower than predicted, with SRB separation, entry, deceleration and water impact occurring as planned. Both SRB's were recovered successfully. Performance of the SSME's, ET, and main propulsion subsystem (MPS) was also nominal, with main engine cutoff (MECO) occurring 515 seconds after SRB ignition. ET separation was nominal and entry occurred with the ET impacting within the targeted footprint.

A problem occurred after ascent when a propellant leak caused the failure of forward vernier reaction control subsystem (RCS) thruster F5R at 220:14:43:21 G.m.t. The thruster was annunciated as "Fail Leak" and deselected by the RCS redundancy management (RM). The F5 vernier thruster manifold was closed to isolate the leak, and the primary thrusters were used for attitude control for the remainder of the mission.

Problems that were tracked during the mission included the Pilot's seat which had a brake or clutch failure during ascent. This condition required the readjustment of the seat during the ascent period. An in-flight maintenance procedure (IFM) was performed on the Pilot's seat. The procedure was completed satisfactorily, and as a result, there was no concern for use of the seat during entry.

The forward RCS heater on vernier thruster F5L failed on at 222:06:00 G.m.t. Data show that the temperature never dropped below the thermostat's lower limit, indicating that the thermostat had failed. The thermostat failure did not affect the RCS or mission operations.

The S-band power amplifier (PA) 2 output power degraded throughout the mission with the power output decreasing from 117 W at lift-off to 60 W at landing. Power amplifier 1 was placed in standby for use if required. Loss of PA 2 would have resulted in the loss of redundancy in the S-band communications, but would not have impacted the mission in any other manner. Also, in the area of communications, an echo appeared on the uplink voice. This echo condition caused no significant problem to communications.

Following the potable water dump at 222:09:04 G.m.t., the supply water dump valve failed to close when switched off by the crew. The dump was terminated by closing the dump isolation valve, and an air purge of the line was performed to remove all water downstream of the isolation valve. All future water dumps through the valve were canceled and the excess water was dumped through the flash evaporator subsystem.

The teleprinter cable shorted at 224:15:00:10 G.m.t. As a result, a workaround configuration for three of the crewmen's suit fans (CDR, MS1, and MS2) that use the same dc power outlet was implemented for entry.

All final entry preparations and stowage were completed, and the orbital maneuvering subsystem (OMS) deorbit maneuver was performed as planned with a firing duration of 138.9 seconds and a differential velocity of approximately 260.7 ft/sec.

Entry interface occurred at the nominal time, and all subsystem performance and entry operations were normal. Main landing gear touchdown occurred at

225:13:37:09.12 G.m.t. (8:37:09.12 a.m. c.d.t.) on lakebed runway 17 at Edwards Air Force Base, CA. The landing speed of 156 KEAS was approximately 30 knots slower than experienced previously and about 40 knots slower than nominal. Nose landing gear touchdown followed 5 seconds later with wheels stop at 225:13:37:53.11 G.m.t. The rollout was nominal in all respects.

All postflight subsystem reconfigurations were completed as planned with the APU's operating for 14 minutes 15 seconds after landing. The 5-day mission was successfully concluded when the crew egressed the Orbiter at 225:14:29:40 G.m.t. (August 13, 1989).

All eleven of the development test objectives (DTO's) assigned to the mission were accomplished. The modular auxiliary data system/Orbiter experiments (MADS/OEX) recorder functioned properly during all data-takes. Initial reports indicate all seven of the detailed supplementary objectives (DSO's) assigned were accomplished, but data are still being evaluated.

SOLID ROCKET BOOSTER PERFORMANCE

All SRB systems performed as expected. The SRB prelaunch countdown was normal. SRM propulsion performance was well within the required specification limits, and propellant burn rates for both SRM's were near nominal. SRM thrust differentials during the buildup, steady-state, and tailoff phases were well within specifications. All SRB thrust vector control (TVC) prelaunch conditions and flight performance requirements were met with ample margins. All electrical functions were performed properly. No SRB or SRM Launch Commit Criteria (LCC) or Operations and Maintenance Requirements and Specification Document (OMRSD) violations were noted.

The SRB flight structural temperature measurement response was as expected. Postflight inspection of the recovered hardware indicated that the SRB thermal protection system (TPS) performed properly during ascent with little TPS acreage ablation.

SRB separation subsystem performance was entirely normal with all booster separation motors (BSM's) expended and all separation bolts severed. The entry and deceleration sequence was properly performed on both SRB's. The SRM nozzle jettison occurred after frustum separation and subsequent parachute deployments were satisfactory. All drogue and main parachutes were recovered. During SRB recovery operations, retrieval ship personnel reported that an aeroheat shield door was missing from one BSM (located in the lower right position of the BSM cluster) on the left SRB frustum (Anomaly STS-28-B-1). The attach ring section of the BSM cover was shipped to MSFC for failure analysis, and preliminary data indicate that the cover was lost well after SRB separation.

Four additional flight anomalies were identified as a result of observed damage that was found during postflight inspection of the SRB's and SRM's. One anomaly was found on the left SRB ETA ring where 18 randomly located bolts which connect the web to the SRM stub were found to be finger tight (Anomaly STS-28-B-2). A crack was found on the left SRB thrust vector controller tilt-system lower frame attachment clevis (Anomaly STS-28-B-3). The third anomaly was a small depression located at 220 degrees on the inner primary seal on the aft face of the inner Gask-O-Seal on the right SRM igniter (Anomaly STS-28-M-1). Also, a ply-separation anomaly was identified in the internal insulation of the right SRM aft center segment (Anomaly STS-28-M-2).

EXTERNAL TANK PERFORMANCE

All objectives and requirements associated with the ET support of the launch countdown and flight were accomplished. Propellant loading was completed as scheduled, and all prelaunch thermal requirements were met. TPS acreage performance was as expected for the existing ambient conditions, and there was no violation of ice/frost criteria. There was no acreage ice on the ET.

The ET pressurization system functioned properly throughout engine start and flight. The minimum liquid oxygen ullage pressure experienced during the period of the ullage pressure slump was 15.5 psig.

ET flight performance was excellent. All electrical and instrumentation equipment on the ET performed properly throughout the countdown and flight. The ET tumble system was activated for this flight. ET entry was normal with breakup and impact within the target footprint. No anomalies were identified from ET data.

SPACE SHUTTLE MAIN ENGINE PERFORMANCE

All prelaunch Space Shuttle main engine (SSME) purge operations were executed successfully. All SSME parameters were normal throughout the prelaunch countdown, comparing well with values observed on previous flights. The engine-ready conditions were achieved at the proper time, all LCC were met, and engine start and thrust buildup were normal.

Flight data indicate that SSME performance during mainstage, throttling, shutdown, and propellant dump operations was normal. All three engines started and operated normally. The high pressure oxidizer turbopump and high pressure fuel turbopump temperatures were normal throughout the period of engine operation. The SSME controllers provided proper control of the engines throughout powered flight. Engine dynamic data generally compared well with previous flight and test data. All on-orbit activities associated with the SSME's were accomplished satisfactorily. There were no failures or significant problems identified.

SHUTTLE RANGE SAFETY SYSTEM PERFORMANCE

Approximately T-11 hours before the planned Shuttle Range Safety System (SRSS) power up, a battery temperature measurement (B55T1505C) on the left SRB range safety system failed off-scale low, indicating temperatures in the 18-19 °F range for a period of 10 minutes. The sensor then went to the expected range for the battery (88-90 °F) and operated properly for the remainder of the flight. No further problems with the measurement were identified during the remainder of the countdown. All prelaunch testing was completed as planned and the operation of the SRSS during the flight was satisfactory.

ORBITER PERFORMANCE

The following paragraphs discuss the Orbiter subsystem performance and provide a reference to the closeout for each identified failure on the Problem Tracking List (Table II).

MAIN PROPULSION SUBSYSTEM

The overall performance of the main propulsion subsystem (MPS) was excellent. All pretanking purges were properly performed, and all liquid oxygen and liquid hydrogen loading was completed with only one stop flow. During the liquid hydrogen replenish phase, the liquid hydrogen chilldown valve was inadvertently closed when the stop step key on the launch processing system console was accidentally hit. As a result, the system was placed in a "safed" condition by operations personnel without acknowledgment over the communications network. During the safing operation, the liquid hydrogen chilldown valve, which is in the line used for replenish flow, was closed, thereby terminating the flow of liquid hydrogen to the ET for a short period of time. After 91 seconds, the liquid hydrogen fill system was brought back up and the valve was reopened, reestablishing flow to ET. There were no adverse affects on the loading operations as a result of this incident.

The prepressurization and pressurization systems performed satisfactorily; however, during MPS helium tank pressurization, the engine 2 helium bottle pressure reached a peak of 4490 psia (LCC limit is 4500 psia). To allow this pressure to remain within limits, the helium fill system was shut off. This action, which did not affect the performance of the flight hardware, remains under investigation.

Calculated propellant loads were very close to the inventory loads. During the preflight operations, no significant hazardous gas concentration was detected, except that the maximum hydrogen levels in the Orbiter aft compartment reached, but did not exceed, the LCC limit of 500 ppm. In the OV-102 vehicle's previous flight and test history, the hydrogen concentration has typically been higher in the aft compartment than the other Orbiters in the fleet, and the data obtained during this mission are comparable with previous data for this vehicle. Because of the concern over this high concentration, agreement was reached that should there be a hold at T-31 seconds, the maximum concentration limit would be raised to 600 ppm with the LCC being exceeded. However, it was not necessary to raise the limit as there was no hold at T-31 seconds.

On this flight (for the second time), prepressurization of the liquid oxygen tank was intentionally reduced 2 psi (trip level reduced from 20.5 psig to 18.5 psig) to prevent the gaseous oxygen flow control valves from closing during the engine start transient. As planned, the gaseous oxygen flow control valves stayed open during the engine start sequence and the early part of ascent and performed normally throughout the remainder of the flight. The minimum liquid oxygen ullage pressure experienced during the period of the ullage pressure slump was 15.5 psig. The SSME 1 gaseous hydrogen flow control valve responded sluggishly during the first 2 minutes of powered flight (Flight Problem STS-28-28). The valve would not fully stroke when the engines were at full throttle and did not respond for three cycles when commanded during the throttle bucket. Also, the gaseous oxygen pressurization line pressurized slowly during entry (Flight Problem STS-28-29).

Three MPS-related instrumentation failures occurred during the countdown and mission operations. The facility high-point bleed temperature measurement (GLHT4119A) read consistently low throughout loading operations. This sensor provides the only backup for monitoring LCC 6.2.1-09, and thus could become critical if the cause for the failure is not found. Two additional MPS instrumentation sensors failed during ascent. The SSME 2 liquid hydrogen inlet temperature sensor (V41T1201C) failed off-scale high (Flight Problem STS-28-05a). The SSME 3 gaseous hydrogen outlet temperature sensor (V41T1361A) operated erratically throughout ascent (Flight Problem STS-28-05d).

REACTION CONTROL SUBSYSTEM

Performance of the reaction control subsystem (RCS) was satisfactory throughout the mission, although three problems were noted. A total of 4610 lb of propellant was used during the mission including the forward RCS propellant dump through the forward RCS prior to entry.

Forward RCS vernier thruster F5R was annunciated "fail leak" about 2 hours into the mission and was deselected by the RM (Flight Problem STS-28-03). The oxidizer and fuel injector temperatures decreased below the 130 °F RM limit with the oxidizer temperature leading. The chamber pressure continued to increase during this period of decreasing temperatures which is indicative of propellant freezing and temporarily plugging the nozzle. The F5R thruster manifold was closed for the remainder of the mission, and the primary thrusters were used for attitude control.

The right RCS oxidizer P1 helium pressure transducer (V41T1201C) exhibited erratic behavior from 7 days prior to lift-off and until 30 minutes into the mission (Flight Problem STS-28-05b). Following this time period, the indicated difference between the pressure 1 and 2 transducer steadily decreased for the remainder of the mission.

The forward RCS vernier thruster F5L heater remained on as indicated by the temperature not dropping to the lower thermostat set point (Flight Problem STS-28-07). The failure of the thermostat did not affect the mission.

During the changeover from A leg to B leg regulators, the left oxidizer helium isolation valve A leg closed without a command when the B leg was opened. This phenomenon has been observed on several occasions during testing at White Sands Test Facility and KSC. The condition is due to mechanical shock (water hammer effect) caused by pressure equalization in the lines between the valves and regulators. This effect results from a procedural change made for this flight that will now be changed back to the original procedure.

ORBITAL MANEUVERING SUBSYSTEM

The OMS performed in accordance with the specifications throughout the mission. Four firings were performed, two of which were with both engines, one was with the left-hand engine, and one was with the right-hand engine. A total of 6,139 lb of oxidizer and 3571 lb of fuel were used during the firings.

This vehicle was the first to have crossfeed-line pressure transducers for use in determining line-pressure excursions. These sensors provided valuable data for analysis of OMS crossfeed operation. These pressure transducers allowed verification of the operation of the ac-motor-valve relief devices.

The right OMS fuel quantity gauge indicated approximately 5.7 percent high during and after the deorbit maneuver (Flight Problem STS-28-17).

POWER REACTANT STORAGE AND DISTRIBUTION SUBSYSTEM

The power reactant storage and distribution subsystem (PRSD) operated satisfactorily throughout the mission and no problems were noted. At lift-off, the PRSD subsystem, consisting of three tank sets, contained 2348 lb of oxygen and 273 lb of hydrogen, of which 1126.5 lb of oxygen and 144.9 lb of hydrogen were supplied to the fuel cells, and 45 lb were used for breathing oxygen. Remaining reactants at landing were adequate to provide at least a 90-hour extension of the mission at average power levels.

FUEL CELL POWERPLANT SUBSYSTEM

The fuel cell powerplant subsystem performed nominally and fulfilled all electrical requirements throughout the mission. The average electrical power load was 14 kWh, and the total energy provided was 1694 kWh. In meeting the electrical requirements, the fuel cells produced 1271 lb of water. The fuel cells operated 159 hours in support of the mission, and were shut off between 25 and 26 hours after landing.

The fuel cell 1 flowmeter failed at 221:01:30 G.m.t., but did not impact fuel cell operations (Flight Problem STS-28-05c). The output of the flowmeter initially drifted high with some upper-limit excursions before failing off-scale high.

AUXILIARY POWER UNIT SUBSYSTEM

The auxiliary power unit (APU) subsystem performed in an excellent manner during ascent, flight control system checkout, and entry and landing operations. APU 1 operated for 1 hour 42 minutes and APU 2 and APU 3 each operated for 1 hour 16 minutes 48 seconds, of which 14 minutes 15 seconds were after landing. A total of 548 lb of fuel was used during the 4 hours 15 minutes 36 seconds of APU operation.

The APU 2 fuel isolation valve B indicated open during preflight operations and throughout the flight (Flight Problem STS-28-12). The valve was verified to be functioning properly during prelaunch and postlanding testing. Also, the APU 1 fuel test line temperature was high (90 to 92 °F) and over the fault detection annunciator (FDA) limit of 90 °F for several cycles (Flight Problem STS-28-18).

APU no.	Ascent		FCS checkout		Entry		Total	
	Run time, min	Consumption, lb	Run time, min	Consumption, lb	Run time, min	Consumption, lb	Run time, min	Consumption, lb
1	18.4	44	4.2	10	79.4	141	102.0	195
2	18.4	49	-	-	58.4	119	76.8	168
3	18.4	54	-	-	58.4	131	76.8	185
	55.2	147	4.2	10	196.2	391	255.6	548

A slight return line pressure oscillation was observed on the four brake pressures supplied by APU 2. This oscillation was seen on the previous flight of OV-102 and is within limits. Evaluation of this condition continues.

HYDRAULICS/WATER SPRAY BOILER SUBSYSTEM

The hydraulics/water spray boiler (WSB) subsystem performed nominally during the STS-28 mission. The postlanding hydraulics load test was nominal. The load test on future missions will be performed every five flights of the vehicle.

On the second day of the mission, the hydraulic system 2 unloader valve operation was out-of-specification and the cause is under investigation (Flight Problem STS-28-23).

PYROTECHNICS SUBSYSTEM

All pyrotechnics subsystems functioned as designed and all separations occurred as planned.

ENVIRONMENTAL CONTROL AND LIFE SUPPORT SUBSYSTEM

Performance of the environmental control and life support subsystem (ECLSS) was satisfactory.

The atmospheric revitalization system air and water coolant loops performance was normal. The CO_2 partial pressure was maintained below 3.1 mm Hg. The cabin air temperature and relative humidity peaked at 83 °F and 46.4 percent, respectively. However, the crew did report during the first day that they were cool and analysis of the cabin temperature controller sensor showed that it was biased high by the warm flight-deck avionics. The cabin temperature controller was operated in the manual mode after the first night in an attempt to maintain acceptable temperatures for the crew sleep period.

The pressure control system operated normally, maintaining the cabin pressure and PPO_2 within normal limits, and the cabin leak rate was also nominal.

The active thermal control system (freon loops, radiators, flash evaporators, and ammonia boiler systems) operated nominally. However, while performing development test objective (DTO) 0118, the radiator panel outlet temperatures dropped to -60 °F (loop 1) and -70 °F (loop 2) accompanied by a drop in flow rates in each loop (Flight Problem STS-28-15). The flow rates recovered when the panels were warmed up above -60 °F.

The supply and waste water subsystems functioned acceptably. The supply water was managed successfully through use of the overboard dump and the use of the flash evaporator system after failure of the dump valve following dump 4. (Flight Problem STS-28-09). The supply water dump line isolation valve was closed to terminate the water dump. The crew performed an in-flight maintenance (IFM) procedure which cleared the line of water. The supply water was dumped through the flash evaporator system for the remainder of the mission.

Data were also collected on iodine levels in the drinking water using the potable water iodine detector. The crew reported that iodine levels were excessive (Flight Problem STS-28-20), and that the water tasted bad. At the end of the flight, the drinking water had a 'tannish' color.

The supply water tank B quantity transducer was erratic between 8 and 70 percent quantity during the last half of the mission (Flight Problem STS-28-05e). This indication was similar to the waste tank quantity transducer which exhibited the same trait at precisely 89.2-percent quantity. The erratic operation of the waste water tank transducer was known prior to flight and was flown in that condition.

The supply water dump line B heaters were cycling within the 90 °F to 110 °F control band of the over-temperature thermostat, indicating that the primary controlling thermostat may have failed closed (Flight Problem STS-28-13).

The crew experienced sneezing when their heads were near windows W1 and W2 (Flight Problem STS-28-21). Biologists have taken air and surface samples in an attempt to isolate the cause of this crew discomfort.

SMOKE DETECTION AND FIRE SUPPRESSION SUBSYSTEM

The smoke detection and fire suppression subsystem functioned normally with no adverse conditions noted. The left-hand flight deck smoke detector registered a slight response to the teleprinter cable short. Also, the avionics bay 2 smoke detector A output displayed a negative value, indicating degradation and out-of-specification operation (Flight Problem STS-28-14).

AVIONICS SUBSYSTEMS

The avionics subsystems performed in an acceptable manner with several problems noted.

During prelaunch operations, abort light B on panel F6 did not illuminate (Flight Problem STS-28-06). Prior to flight, the failure was isolated to either channel 31 of the annunciator control assembly or the B bulbs, and the condition was accepted for flight.

Also during prelaunch operations, the nose landing gear no-weight-on-wheels proximity sensor failed to the off condition, indicating weight on the nose gear (Flight Problem STS-28-04). The measurement had been toggling between on and off prior to the failure. The condition cleared after orbital insertion, but returned later in the flight. The presence of the off condition caused a dilemma at touchdown that affected the flight control system gains and prevented automatic engagement of nose wheel steering. Rather than change the onboard software in flight, the decision was made to follow standard crew procedures for manually activating nose wheel steering. These were followed and the nose wheel steering operated nominally throughout rollout.

When transitioning from OPS 9 to OPS 1 during countdown activities, two input-output errors were logged against master memory unit (MMU) 1 (Flight Problem STS-28-01). Data indicate that these were failure-to-read errors on area 1 of the MMU 1 tape. After recycling to OPS 9, a general purpose computer memory (GMEM) read-write procedure was used to read OPS 1 from area 2 of the MMU tape. Following this, the system was cycled to OPS 1 and a miscompare between the main engine thrust vector controller (TVC) and the main engine bell positions was noted. The system was again cycled to OPS 9 and the TVC commands were reset, after which the system was cycled back to OPS 1 and all systems operated satisfactorily.

During the same time frame of the MMU problem, the network signal processor also (NSP) had a frame synchronization error. These prelaunch NSP frame synchronization errors were also noted on the first pass over Bermuda and Indian Ocean tracking stations (Flight Problem STS-28-25). The initial evaluation prior to launch indicated a ground station problem in all cases, but evaluation is continuing.

During postflight debriefings, the crew reported that they felt a thump/thud at the first transition to OPS-1 discussed in the previous paragraph (Flight Problem STS-28-27). The crew stated that the whole vehicle shook. The time of the occurrence is coincident with the aerosurfaces moving from the droop position to the null position.

The -Y star tracker experienced a "pressurization failure" built-in test equipment (BITE), which indicates that the internal pressure of the tracker housing was less than 14.7 psia (Flight Problem STS-28-10). Nominal pressure for this instrument is 17.2 psia. This same condition occurred during prelaunch operations, and at that time the BITE indication was cleared when the instrument was repressurized.

The inertial measurement unit (IMU) 1 failed RM due to large drift rates. New drift compensations were calculated for use after the first IMU alignment. The new calculations resulted in the IMU providing correct inertial data for the rest of the mission.

The S-band power amplifier 2 (PA 2) power output degraded during the mission from 117 W to 60 W, but provided satisfactory communications through landing (Flight Problem STS-28-08). Power amplifier 1 was placed in standby for use should PA 2 have failed. Should switchover to PA 1 have been required, PA 1 would have been cross-strapped into the operating string.

A dc power cable from the teleprinter to a Orbiter utility outlet shorted near the connector to the outlet (Flight Problem STS-28-11). A short-duration low-energy current spike was observed on main bus C. The circuit protection operated within design parameters and did not trip the associated 10 A circuit breaker. The crew reported that several sparks flew through the cabin and that the crew could detect light amounts of smoke when the short circuit occurred. Use of the teleprinter was discontinued for the remainder of the mission.

Postflight data analysis indicated that both radar altimeters lost lock at 26 feet and regained lock at 16 feet (Flight Problem STS-28-16).

Data evaluation indicated that five operational instrumentation measurements were miswired (Flight Problem STS-28-05f). The measurement numbers were V58T0130, V58T0169, V58T0269, V58T0369, and V58T0384.

AERODYNAMICS

The Orbiter vehicle aerodynamic responses were as expected during ascent and entry. However, an unusual low-frequency aileron movement was noted in the Mach 20 to Mach 10 range during entry (Flight Problem STS-28-30). Analysis of this problem is continuing.

MECHANICAL SUBSYSTEMS

All mechanical systems operated nominally during the mission. Failure of the nose gear weight-on-wheels proximity switch during prelaunch operations produced dilemmas in both the weight-on-wheels and weight-on-nose-gear events during landing. The crew followed an alternate standard procedure for engaging nose wheel steering. The primary effects on the landing deceleration subsystem were that half of the eight brake channels were enabled prior to main gear touchdown, a condition that would allow brake application before touchdown, and manual engagement of nose wheel steering was necessary rather than the normal automatic engagement at nose gear touchdown. No brake applications were noted prior to main gear touchdown.

Main gear touchdown velocity (156 KEAS) was 30 knots below that experienced on previous flights and 40 knots below nominal. This resulted in low nose-gear-touchdown and brake-application velocities. The low nose-gear-touchdown velocity resulted in a slightly higher than usual pitch rate at nose gear contact, but within limits. Brake usage was normal with minimal pressure applications. The low brake application velocity combined with the high lakebed rolling coefficient of friction resulted in very low brake energies. The brake systems were in excellent condition with no visible signs of damage.

The right main gear had a 1.2 second greater deployment time than the left main gear, but both gear deployed well within specifications.

STRUCTURES SUBSYSTEMS

The structural subsystems supported the mission in a satisfactory manner; however, two problems were noted during the evaluation.

a. Evaluation of launch films, specifically camera E-207, revealed apparent deflections at the trailing edge of the body flap (Flight Problem STS-28-24). Photographic analysis indicates frequencies of 7.9 ($\pm$ 2.3) Hertz.

A modal test, boroscope inspection, and a deflection test have been performed on the OV-102 body flap. The body flap will be removed and the actuators disassembled and inspected to determine the origin of the excessive noise heart during the modal test. The photographic analysis section of this report contains a more detailed discussion of the findings in this area.

b. The postflight inspection of the Orbiter structure revealed an area of possible high heat input near the aft right ET umbilical door frame structure (Flight Problem STS-28-26).

THERMAL PROTECTION SUBSYSTEM AND AEROTHERMODYNAMICS

The Orbiter thermal protection subsystem (TPS) performed in a nominal manner based on structural temperature responses, and some tile surface temperature measurements. The boundary-layer transition from laminar to turbulent flow was unusual in that it occurred as early as 900 seconds after entry interface in areas toward the aft end of the Orbiter, and at 1200 seconds after entry interface in areas toward the forward fuselage. This occurrence did not result in any TPS or structural temperature limits being violated.

Overall, the TPS damage was less than that normally seen and only minor in nature. The Orbiter sustained a maximum of 76 hits of which 20 had a major dimension of 1 inch or greater. Debris impact damage to the lower surface was minimal with 51 hits, 14 of which had at least one major dimension of 1 inch or greater. The majority of the lower surface damage was concentrated aft of the main landing gear doors. The base heat shield peppering was also minimal. Three white streaks were observed on the right-hand wing leading edge, and two black streaks with deposits were found on the left-hand wing leading edge. Based on the severity of damage as indicated by surface area and depth, this Orbiter received less than the average amount of damage.

Other items found in the inspection showed the advanced felt reusable surface insulation (AFRSI) modification was in excellent condition with no obvious blanket damage. The reinforced carbon carbon (RCC) chin panel was also in excellent condition. The thermal barrier between the chin panel and the nose cap was compressed with some minor fraying along the outer mold line. There was no indication of flow or slumping. Overall, the elevon-cove tile modification appeared nominal, except for evidence of outgassing in the left-hand inboard cove. The right-hand cove also showed some evidence of minor outgassing. The upper midfuselage, payload bay doors, OMS pods, and vertical stabilizer all looked nominal with minor damage in some cases and no damage in the remaining.

Evaluation of film from the ET well separation camera revealed that the TPS along the entire forward portion of the liquid oxygen umbilical was displaced (Flight Problem STS-28-31). The displaced area of TPS was 18 inches wide by 8 inches long by 2 inches deep, and remained loosely attached by the fire barrier coating.

Orbiter windows 2 and 4 appeared hazy. Window 3 was heavily hazed, and a deposit was observed on window 5. Laboratory analyses will be performed on samples taken from all windows.

CREW EQUIPMENT AND GOVERNMENT FURNISHED EQUIPMENT

The flight crew equipment functioned satisfactorily except for the Pilot's seat operation during ascent. Following SRB separation, the Pilot's seat was observed to be moving aft (Flight Problem STS-28-02). When the Pilot could no longer reach the MPS ac switches, the seat was moved forward about 3 inches. The seat immediately began moving aft to the stops. After orbital insertion, the crew performed an IFM to determine if an electrical problem existed in the positioning switch; however, the seat performed satisfactorily during the conduct of the procedure. Likewise, the seat operated properly during entry and landing operations.

During postflight debriefings. the crew reported that the rubber grommet on the wet trash volume came loose (Flight Problem STS-28-19). The grommet was stowed in the dry trash volume for return. The grommet was recovered and evaluation to determine the cause is continuing.

The 16 mm umbilical well camera with the 10 mm lens was inoperative during the mission (Flight Problem STS-28-22). The film broke 1.5 seconds after the camera was activated during ascent.

PHOTOGRAPHIC AND VIDEO ANALYSIS

A total of 22 video cameras provided data of the launch and ascent environment. An evaluation of these data identified no anomalies. Video data of landing activities were also reviewed and no anomalies were identified.

A total of 73 35 mm and 16 mm photographic films of launch and ascent were reviewed as well as 11 landing films. In addition, data were obtained from two of three umbilical well cameras. The umbilical well 16 mm camera with the 10 mm lens had a film break 1.5 seconds into ascent and provided almost no data (Flight Problem STS-28-22).

Analysis of the launch and ascent films revealed one significant area of interest which involved excessive movement of the body flap (Flight Problem STS-28-24). Film from camera E-207 (35 mm) showed a peak-to-peak amplitude for body flap movement of 9 +/- 4 inches. A total of 31 cycles were observed with a frequency of 7.9 +/- 2.3 Hertz. Analysis of this condition continues.

ORBITER EXPERIMENTS

The Orbiter Experiments (OEX) complement flown on STS-28 consisted of the Aerodynamic Coefficient Identification Package (ACIP), the Shuttle Entry Air

Data System (SEADS), the Shuttle Infrared Leeside Temperature Sensing (SILTS), and the Aerothermal Instrumentation Package (AIP). Quick-look assessments of the STS-28 data indicate very good performance by all of the OEX hardware. The linear accelerometers and rate gyros in the ACIP exhibited normal performance, as did two of the three angular accelerometers. The Y-axis angular accelerometer data indicate a significant sensitivity to linear acceleration. This problem has been noted on previous missions to a lesser extent, but because of the limited requirements for angular data and the fact that these data may be obtained by other means, the three-axis accelerometer package will continue to flown in its present condition.

The SILTS data evaluation results are discussed under DTO 0901 in this report. Analysis results from the SEADS experiment are discussed under DTO 0903 in this report.

DEVELOPMENT TEST OBJECTIVES AND DETAILED SUPPLEMENTARY OBJECTIVES

Eleven development test objectives (DTO's) and six detailed supplementary objectives (DSO'S) were assigned to STS-28. All eleven of the DTO's and all six of the DSO's were accomplished, and preliminary results of the DTO's and DSO's are covered in the following paragraphs.

DEVELOPMENT TEST OBJECTIVES

DTO 0118 - Cold Soak of Observation Window.- The purpose of this DTO was to obtain data in a cold environment to determine observation-window-seal thermal response on OV-102 following removal of the emergency egress system after STS-9. The data obtained will be used to verify a preflight analysis and to better define observation-window-seal thermal constraints for the current OV-102 window configuration.

Two separate periods of tail-sun with top to space and in the orbit-rate roll mode were flown. The first period had a duration of 4 hours and the second had an 8-hour duration. In each case, the thermal response of the Orbiter canopy, as shown on V09T1524 sensor, was similar to the response in the same attitude during STS-3. During the 8-hour attitude hold, the canopy was initially at 39 °F and the temperature dropped to -19 °F at the end of the DTO. During the STS-3 mission, the canopy was initially 29 °F at the end of the 24-hour period of data taking. Based on the analysis of data from the two flights, removal of the emergency egress system did not have a significant effect on the OV-102 canopy or the observation window temperatures, but the data do indicate that the current configuration is somewhat cooler than the STS-3 configuration.

DTO 0236 - Ascent Aerodynamic Distribution Loads Verification on OV-102.- The purpose of this DTO was to obtain ascent flight pressure data to compare with the predictions in the IVBC3 aerodynamic data base. Data have been recorded, plotted, and a preliminary review of the plots has been made. However, data analysis is still in progress.

The OV-102 vehicle is instrumented with 205 pressure transducers on the wing upper and lower surfaces. During STS-28 ascent, the pressure at each of these transducers was recorded using the modular auxiliary data system (MADS). Of the 205 transducers, 141 performed well, 21 went off scale at some point, and 43 failed. Data from 24 of the 43 failed sensors were passed through strain gage signal conditioners. Since the amplifiers for the output signal from these signal conditioners were not adjusted prior to flight, the data were deemed unusable. A preliminary estimate has been made of the uncertainty in the pressure read by the transducers during ascent. For STS-28, the standard deviation is equal to 0.137 psi. A similar uncertainty existed on the last OV-102 flight (STS 61-C). Upon completion of data analysis, a DTO summary report will be published.

<u>DTO 0301D - Ascent Structural Capability Evaluation</u>.- The series of tests to fulfill this DTO was required to verify the adequacy of the Shuttle structure at (or near) design conditions during lift-off and ascent with near-maximum-weight payloads. Data were collected to determine flight loads, demonstrate the operational capability of the structural system, and determine if any unacceptable dynamic effects exist that will require hardware or software changes.

Operational and MADS data were recorded during lift-off and ascent, and the computer compatible tapes have been provided to the structures community for further evaluation and analysis to obtain the required loads. Final processed data will be analyzed by the DTO sponsors after which a DTO summary report will be issued by the sponsors.

<u>DTO 0303D - Reinforced Carbon Carbon Life Evaluation</u>.- The purpose of this DTO was to support mission-life determinations of the reinforced-carbon-carbon (RCC) nose cap and wing leading edge, as well as verify the analytical mass-loss predictions and mission life for other RCC components. This was a data-only DTO that required the acquisition of MADS data during the entry phase. In addition, a postlanding requirement existed for removal of the nose cap and two of the wing leading edge panels to obtain access to the RCC mass-loss buttons (3/4 inch discs) that are in contact with the parent RCC components at these critical heating areas. These mass-loss buttons are normally removed for weighing and dimensional checks after every fifth flight after which the same buttons are reinstalled in the same locations until at least 20 flights have been achieved. The MADS data collected for this DTO appear to be usable for the required analysis.

<u>DTO 0307D - Entry Structural Capability</u>.- The objective of this DTO was as follows:

a. Collect data during entry and approach and landing to verify the adequacy of the structure at or near design conditions;

b. Demonstrate structural system operational capability;

c. Determine flight loads;

d. Verify the stress/temperature response of critical structural components.

Operational instrumentation and MADS data were recorded during the entry and approach and landing, and the data are being processed. Final processed data will be analyzed by the DTO sponsors after which a DTO summary report will be published by the sponsors.

DTO 0312 - External Tank Thermal Protection System Performance.- Requirements for this DTO consisted of obtaining photography of the ET and SRB for purposes of thermal protection system (TPS) and debris source assessment. Equipment used to accomplish this experiment consisted of two 16 mm cameras in the left Orbiter/ET umbilical well (for SRB and ET assessment); a 35 mm still camera in the right umbilical well (for ET protuberance assessment); and a crew hand-held 70 mm camera (for ET photography after separation). Crew-initiated Orbiter maneuvers were accomplished to enhance the photography.

Preliminary analysis of film from one of the 16 mm cameras (with fish-eye lens) indicates acceptable quality with no obvious anomalies on the SRB's or ET. The 35 mm camera also worked well, providing good quality images of the right-side protuberances of the ET. Initial analysis does not indicate any excessive divoting of the TPS. However, analysis does indicate that consideration should be given to changing the frame rate of that camera from two frames per second to one frame per second to enhance the prospects for obtaining coverage of the ET nose cone area. The current excessive overlap between frames at 2 frames per second should allow this without any loss of intelligence.

The second 16 mm camera failed during ascent (Flight Problem STS-28-22). Postflight analysis indicates that the film broke 1.5 seconds into ascent. A contributing cause was the age of the very thin film, and the length of time (2 months) between film installation and lift-off of the vehicle.

The 70 mm film yielded 14 frames of the ET after separation. The pictures show the ET tumbling and capture all sides of the ET. Preliminary analysis has begun to determine if any TPS anomalies are shown. Final analysis results will be published by the JSC and KSC sponsors of the DTO.

DTO 0334 - Aft Bulkhead Thermal Blanket Evaluation.- Following completion of the STS-26 and STS-27 missions, results of inspections at KSC showed that several aft-bulkhead thermal-blanket closeout snaps were open, and blankets were bulging in some areas. In addition, one of the blankets at the top center of the aft bulkhead was damaged. The upper row of blankets was redesigned after STS-27.

The purpose of this DTO was to obtain photographic documentation to determine the phase of the mission when these anomalies occurred. Data were obtained on OV-104 (STS-30) which was flown with the redesigned blankets and no damage occurred to these blankets. However, some of the unmodified blankets were damaged. The OV-102 vehicle aft bulkhead has a different structural design that requires seven upper blankets rather than the four upper-blanket configuration on OV-103 and OV-104. The redesigned blankets on OV-102 had no anomalies, however, damage was found on two of the unmodified blankets installed beside and below the redesigned blankets on the port side of the aft bulkhead. This damage was found after the vehicle was returned to KSC.

No visible blanket contamination was reported or recorded on-orbit or during the payload bay inspection for contamination after return of the vehicle to KSC. Results of this DTO will be published by the DTO sponsors after completion of the analysis.

DTO 0623 - Cabin Air Monitoring.- The STS-28 vehicle cabin atmosphere was sampled with both air cylinders and a solid sorbent air sampler during the mission. After the mission, these air samples were returned to the JSC Toxicology Laboratory for analysis.

Analytical results from the OV-102 cabin atmospheric samples taken during the STS-28 mission indicate that the levels of all contaminant gases present were well below the spacecraft maximum allowable concentration limits. This indicates that the cabin living environment was toxicologically acceptable for human habitation during the mission.

DTO 0631 - Shuttle Beverage Pouch and Galley Adapter Evaluation.- The Shuttle beverage pouch and galley adapter were evaluated on STS-28. The beverage pouch was designed to reduce the trash volume generated from food containers, and the galley adapter was the interface between the galley rehydration station and the beverage pouch. The beverage pouch also requires less weight and volume than the present package.

The new package and galley adapter were used for cold beverages on one mission day and both functioned well. Data collected from the mission are being evaluated. This same DTO will be performed again on STS-34.

DTO 0901 - Orbiter Experiment - Shuttle Infrared Leeside Temperature Sensing.- The objective of the Orbiter Experiment (OEX) Shuttle infrared leeside temperature sensing (SILTS) experiment was to obtain flight data on leeside heating and flow fields on OV-102 in a true entry environment. These data will be compared with wind tunnel test results and theoretical predictions. The addition of flight data will provide a better understanding of aeroheating dynamics with application to future heat shield designs.

On STS-28, the SILTS infrared scanner, mounted on top of the vertical stabilizer, was programmed to view the upper surface of the left wing only. The resulting midrange imaging data were digitized and recorded on the onboard OEX 28-track tape recorder along with data from wing temperature instrumentation mounted in the thermal protection system tiles and in the wing as well as other recorded data including that from the aerothermal instrumentation package (AIP) and the aerodynamic coefficient instrumentation package (ACIP).

Quick-look assessments of the STS-28 data indicate very good performance by all OEX hardware. Oscilloscope displays of the SILTS data indicate high quality thermal imagery; however, extensive processing of the data at Langley Research Center is required to quantify the degree of experiment success. Examination of the SILTS pod and adjacent areas immediately after landing showed no evidence of over-heating to the tiles or to the window or window mount as was evidenced after STS 61-C.

Data from several of the temperature and pressure measurements provided by the AIP indicate that the AIP's dedicated pulse code modulation (PCM) system functioned properly. An assessment of the performance of AIP's pressure and temperature sensors will require a more detailed review of the data from each of the 140 measurements that comprise the AIP. The SILTS data assessment will be performed by personnel from JSC, Langley Research Center, and Rockwell-Downey, and the results will be reported in a separate document.

DTO 0903 - Orbiter Experiment - Shuttle Entry Air Data System.- The purpose of the Shuttle entry air data system (SEADS) Orbiter experiment was to obtain more precise measurements of air data and angles of attack and sideslip at speeds and accuracies not available with the baseline Orbiter air data system.

Early analysis of the data indicates good results from the SEADS experiment. Good clean signals that indicate appropriate pressure decreases during ascent and then later pressure increases during entry were noted. Final evaluation awaits computer processing of the data at Langley Research Center. The results of the analysis will be published in a separate report.

DETAILED SUPPLEMENTARY OBJECTIVES

DSO 457 - Salivary Pharmacokinetics of Scopolamine and Dextroamphetamine.- Two crew members participated in this study and 100 percent of the planned data was collected. Data analysis is in progress, and the results will be reported in a separate document.

DSO 458 - Salivary Acetaminophen Pharmacokinetics.- Two crew members participated in this study and 100 percent of the planned data was obtained. Data analysis is in progress, and the results will be reported in a separate document.

DSO 459 - Otolith Tilt-Translation Reinterpretation.- One crew member participated in this study and 100 percent of the planned data was obtained. No flight hardware problems were experienced. Data analysis is in progress, and the results will be reported in a separate document.

DSO 469 - In-flight Radiation Dose Distribution.- Preliminary inspection of the data suggests that the Tissue Equivalent Proportional Counter (TOPIC) was not functioning properly. The device needs to be calibrated before a definite conclusion can be made. The TEPC accounts for approximately 20 percent of the data for the entire DSO. The remaining 80 percent of the data was successfully obtained with no hardware problems.

DSO 466 - Preflight and Postflight Echocardiography.- Three crew members participated in this DSO, and 100 percent of the planned data was obtained. Data analysis is in progress, and the results will be reported in a separate document.

DSO 467 - Influence of Weightlessness on Baroreflex Function.- Four crew members participated in this study and 100 percent of the planned data was obtained. Data analysis is in progress, and the results of the study will be published in a separate document.

TABLE I.- STS-28 SEQUENCE OF EVENTS

Event	Description	Actual time, G.m.t.
APU activation	APU-1 GG chamber pressure	220:12:32:09.96
	APU-2 GG chamber pressure	220:12:32:10.89
	APU-3 GG chamber pressure	220:12:32:11.89
SRB HPU activation	LH HPU system A turbine speed	220:12:36:32.192
	RH HPU system A turbine speed	220:12:36:32.509
Main propulsion System start	Engine 3 start command to EIU	220:12:36:53.460
	Engine 2 start command to EIU	220:12:36:53.599
	Engine 1 start command to EIU	220:12:36:53.702
SRB ignition command (lift-off)	SRB ignition command to SRB	220:12:37:00.012
Throttle up to 104 percent thrust	Engine 3 command accepted	220:12:37:03.780
	Engine 2 command accepted	220:12:37:03.799
	Engine 1 command accepted	220:12:37:03.782
Throttle down to 66 percent thrust	Engine 3 command accepted	220:12:37:27.302
	Engine 2 command accepted	220:12:37:27.320
	Engine 1 command accepted	220:12:37:27.303
Maximum dynamic pressure (q)	Derived ascent dynamic pressure	220:12:37:49.88
Throttle up to 104 percent thrust	Engine 3 command accepted	220:12:37:59.303
	Engine 2 command accepted	220:12:37:59.321
	Engine 1 command accepted	220:12:37:59.304
Both SRM's chamber pressure at 50 psi	LH SRM chamber pressure mid-range select	220:12:38:58.054
	RH SRM chamber pressure mid-range select	220:12:38:58.812
End SRM action	LH SRM chamber pressure mid-range select	220:12:39:00.612
	RH SRM chamber pressure mid-range select	220:12:39:00.712
SRB separation command	SRB separation command flag	220:12:39:04
SRB physical separation	SRB physical separation	
	LH APU A turbine speed LOS*	220:12:39:04.29
	LH APU B turbine speed LOS*	220:12:39:04.25
	RH APU A turbine speed LOS*	220:12:39:04.33
	RH APU B turbine speed LOS*	220:12:39:04.30
Throttle down for 3g acceleration	Engine 3 command accepted	220:12:44:31.006
	Engine 2 command accepted	220:12:44:30.973
	Engine 1 command accepted	220:12:44:30.994
3g acceleration	Total load factor	220:12:44:30.97
MECO	MECO command flag	220:12:45:35.37
	MECO confirm flag	220:12:45:36.60
ET separation	ET separation command flag	220:12:45:53.80
OMS-1 ignition	Left engine bi-prop valve position	Not required for direct ascent
APU deactivation	APU-1 GG chamber pressure	220:12:50:32.95
	APU-2 GG chamber pressure	220:12:50:34.34
	APU-3 GG chamber pressure	220:12:50:35.31

* loss of signal

TABLE I.- CONCLUDED

Event	Description	Actual time, G.m.t.
OMS-2 ignition	Left engine bi-prop valve position	220:13:14:52.23
	Right engine bi-prop valve position	220:12:14:52.03
OMS-2 cutoff	Left engine bi-prop valve position	220:13:16:38.05
	Right engine bi-prop valve position	220:13:16:38.10
Flight control system checkout		
APU start	APU-1 GG chamber pressure	224:08:18:18.59
APU stop	APU-1 GG chamber pressure	224:08:22:31.52
APU activation for entry	APU-1 GG chamber pressure	225:12:32:00.60
	APU-2 GG chamber pressure	225:12:52:59.26
	APU-3 GG chamber pressure	225:12:53:00.38
Deorbit maneuver ignition	Left engine bi-prop valve position	225:12:36:56.5
	Right engine bi-prop valve position	225:12:36:56.4
Deorbit maneuver cutoff	Left engine bi-prop valve position	225:12:39:14.7
	Right engine bi-prop valve position	225:12:39:14.6
Entry interface (400k)	Current orbital altitude above reference ellipsoid	225:13:05:57.09
Blackout end	Data locked at high sample rate	No blackout because of TDRS
Terminal area energy management	Major mode change	225:13:30:53.11
Main landing gear contact	LH MLG weight on wheels	225:13:37:09.12
	RH MLG weight on wheels	225:13:37:08.12
Nose landing gear contact	NLG weight on wheels	225:13:37:14.17
Wheels stop	Velocity with respect to runway	225:13:37:53.11
APU deactivation	APU-1 GG chamber pressure	225:13:51:23.81
	APU-2 GG chamber pressure	225:13:51:24.28
	APU-3 GG chamber pressure	225:13:51:25.04

TABLE II.- PROBLEM TRACKING SUMMARY

Number	Title	Reference	Comments
STS-28-01	MMU-1 input/output error on OPS-1 transmission	220:11:25 G.m.t. 1M28RF01 IPR-32RV-0012	Two input/output errors were logged against mass memory unit 1 during the transition to OPS-1. The error was a read-tape-data dropout and is considered a tape anomaly. KSC recycled to OPS-9 and performed a GMEM to access area 2 for G1. Subsequent OPS-1 transitions occurred without any errors logged against the MMU's. KSC retest of MMU showed no problems
STS-28-02	Pilot's seat moved aft during ascent	220:12:42 G.m.t. IM28RF02 IPR-32RV-0014	Pilot reported that the seat held during first stage. However, during second stage, the CDR and MS noticed the Pilot's seat moving aft. When the Pilot could no longer reach the ac switches, he moved the seat forward 2 to 3 inches. After the seat was repositioned, it immediately began to drift aft all the way back to the stops. Crew performed an IFM on seat and no electrical or mechanical problems were noted. New motor installed and retested satisfactorily
STS-28-03	Vernier thruster F5R annunciated "fail leak"	220:14:43 G.m.t. IPR-32RV-006 IM28RF03	Vernier thruster F5R was annunciated "fail leak" and deselected by RCS thruster RM. Oxidizer and fuel injector temperatures decreased below 130 °F RM limit. Forward RCS manifold 5 was closed and vernier driver power was turned off. KSC will remove and replace thruster
STS-28-04	Nose landing gear weight-on-wheels (WOW) indication failed off	Prelaunch PR-GNC-2-A-0008 IM28RF04	The nose landing gear no-weight-on-wheels proximity sensor failed to the off condition indicating weight on the nose gear during prelaunch activities. The indication was toggling on and off prior to the failure. The WOW-on indication recovered on orbit, but then returned. SRB SEP pushbutton depressed after main gear touchdown in accordance with standard back-up procedures to eliminate WOW dilemma and engage nose wheel steering. KSC swapped sensors, and proximity sensor repeated failure. Electronic box will be removed and replaced
STS-28-05	Operational instrumentation problems		
a.	Left SSME LH2 inlet temperature failed high (V41T1201C)	220:12:38 G.m.t. IPR-32RV-0007 IM28RF10	During ascent, the LH2 inlet temperature transducer failed off-scale high. KSC will remove and replace if failure is verified
b.	Right RCS helium oxidizer tank pressure 1 failed (V42P3110C)	213:00:00 G.m.t. RP04-A0016 IM28RF05	During prelaunch operations, the pressure indication was erratic. On-orbit, the pressure difference with the P2 measurement steadily decreased during the flight. KSC will remove and replace transducer in accordance with PRCB direction
c.	Fuel cell 1 hydrogen flow indication erratic (V45R0170A)	221:01:30 G.m.t. IM28RF06	Fuel cell 1 hydrogen flow meter output began to drift high about 12 hours after lift-off and exhibited subsequent erratic behavior with intermittent upper limit indications. No mission impact and KSC will submit exception
d.	SSME 3 GH2 outlet temperature erratic (V41T1361A)	220:12:38 G.m.t. IPR-32RV-0008 IM28RF13	During ascent, the GH2 outlet temperature indication was erratic. KSC will troubleshoot and remove and replace
e.	Supply water tank B quantity was erratic (V62Q0420A)	223:08:28 G.m.t. IPR-32RV-0026 IM28RF18	Supply water tank B quantity measurement was randomly erratic throughout the mission
f.	Operational instrumentation measurements miswired	IM28RF19	Evaluation showed five operational instrumentation measurements were miswired. These were V58T0130 (system 1 LH2 retract actuator return line temperature), V58T0169 (system 1 body flap return line temperature), V58T0269 (system 2 body flap return line temperature), V58T0369 (system 3 body flap return line temperature, and V58T0384 (system 3 rudder speedbrake return line. KSC will repair as required

TABLE II.- PROBLEM TRACKING SUMMARY

Number	Title	Reference	Comments
STS-28-06	Abort light B (panel F6) did not illuminate during prelaunch tests.	220:01:40 G.m.t. IPR-32RV-0004 IM28RF07	During prelaunch tests, two of four abort lights on panel F6 did not illuminate. Bulb assembly bad. KSC will remove and replace bulb
STS-28-07	Forward RCS F5L heater failed on	222:06:00 G.m.t. IPR-32RV-0009 IM28RF08	Pod will be removed to replace F5R thruster and F5L heater. No mission impact
STS-28-08	S-band power amplifier 2 RF power output degraded to 60W during mission	222:00:12 G.m.t. IPR-32RV-0011 IM28RF09	Power amplifier RF power output decreased from 117W to 60W during the mission with no mission impact. KSC will troubleshoot and remove and replace bad power amplifier
STS-28-09	Potable water dump valve failed open	222:09:10 G.m.t. IM28RF11 IPR-32RV-0010	The supply water dump valve did not close at the end of the fourth water dump. Dump was stopped and restarted, but valve remained open. Isolation valve was closed to terminate dump. Lines were purged with air and valve still failed to close. Water dumped through flash evaporator for rest of mission. KSC will troubleshoot and remove and replace failed valve
STS-28-10	-Y star tracker pressure failed low	221:05:46 G.m.t. PR-GNC-2-A0012 IM28RF12	A -Y star tracker pressurization fail BITE was annunciated during prelaunch activities, indicating internal pressure below 14.7 psia. Nominal pressure is 17.2 psia. The BITE cleared when unit was repressurized. The BITE reappeared while on-orbit. Vendor will purge and repressurized unit in place
STS-28-11	Main C utility outlet 1 teleprinter short circuit	224:15:00 G.m.t. PR-VJCS-0957 IPR-32RV-0017 FIAR BFCE 29F012	The teleprinter cable shorted out causing a 1.5-second sustained short circuit with a 51A peak for 100 milliseconds on Main C 016. For entry, CDR, MS1, and MS2 rerouted their suit fans to the main B 015 utility outlets. JSC will redesign cable and supply new cables
STS-28-12	APU isolation valve talkback failure	Prelaunch PR-APU-2-A0019 IM28RF14	Anomaly continued during flight. Postflight load test verified valve was open, but talkback failed. Waiver for flight approved
STS-28-13	Supply water dump line thermostat improper operation	220:08:52 G.m.t. IM28RF15 IPR-32RV-0027	Data review following redundant component checkout shows that the supply water dump line heater B may be operating on the over-temperature thermostat. The same signature has been noted on previous flights of OV-102. KSC will remove and replace
STS-28-14	Avionics bay 2 A smoke concentration (V62Q0609A) biased low	220:00:45 G.m.t. IM28RF16	Avionics bay 2 smoke concentration reads low. Self test shows sensor to be functional, but out of specification. KSC changed out sensor
STS-28-15	Low Freon flow (V63T1410A)	224:01:37 G.m.t. IM28RF17 IPR-32RV-0028	Freon loop radiator panel outlet temperature dropped below -60 °F and Freon loop 2 flow degraded about 100 lb/hr (V63R1300A). Freon loop 1 flow degraded about 50 lb/hr (V63R1100A). Freon flow returned to normal as panels reheated. Possible water contamination. KSC will sample both loops
STS-28-16	Radar altimeter 1 and 2 lost altitude indication	Landing IPR-32RV-0025 IM28RF20	During landing flare, both radar altimeters (1 and 2) lost altitude reading at 26 feet. Vendor will go to KSC to troubleshoot altimeters
STS-28-17	Right-hand OMS fuel quantity gauge read high	225:12:39 G.m.t. IPR-32RV-0025 IM28RF21	The right-hand OMS fuel quantity gauge read 5.7 percent high after the deorbit maneuver based on predicted values. Engineering evaluation in progress
STS-28-18	APU 1 test line temperature high	225:13:05 G.m.t. IM28RF22	APU 1 test line temperature was high (90 to 92 °F) and was over the FDA limit of 90 °F for several cycles. Switched to B heaters after FCS checkout per plan and B heaters were almost to FDA limit all the time they were on. Engineering confirmed heaters operating properly. FDA limits will be changed by CR

TABLE II.- PROBLEM TRACKING SUMMARY

Number	Title	Reference	Comments
STS-28-19	Rubber grommet on wet trash volume came loose	IM28RF23 PR-FCS-2-09-0240	The rubber grommet on the wet trash volume came loose. The crew stowed the grommet in the dry trash volume. Grommet satisfactory and reinstalled per print
STS-28-20	Iodine in the drinking water (GFE)	IM28RF24 PR-FCS-2-09-0240	The crew measured greater than 13 ppm iodine concentration in the drinking water through the final 3 days of flight. Crew limited water consumption due to taste of iodine. Redesign in work for long-term solution (8 months to 1 year). Short-term fix is in work
STS-28-21	Crew experienced eye irritation	IPR-32RV-0033 IM28RF25	Crew experienced sneezing whenever a crew member's head was near windows W1 and W2. Biologists collected air and surface samples from windows W1 and W2 and shipped to JSC for analysis. Contents of LiOH canisters sent to JSC for analysis
STS-28-22	Umbilical well camera inoperative (GFE)	Prelaunch	The 16 mm camera with the 10 mm lens in the umbilical well was inoperative. OMRSD requires film advancement every 45 days. Film broke 1.5 seconds into ascent
STS-28-23	Hydraulic system 2 unloader valve operation out of specification	19:00:00 met	Valve cycled at 2350-psi accumulator pressure during prelaunch which was high (should be 2100 psi). During flight, accumulator pressure dropped sharply from 2500 psi to 2350 psi and valve cycled (out of specification). Suspect valve leakage and stiction. This dash number valve has a history of leakage, and an attrition modification exists to change valve to a later configuration. Vendor will failure analyze this component. KSC will replace -0001 valve with -0002 valve
STS-28-24	Body flap excessive deflection during ascent (Camera E207)	00:00:46 met	Film shows excessive deflection (+/- 9 inches) at body flap trailing edge tip. Frequency approximately 7.9 +/- 2.3 Hertz. Low frequency may indicate loss of stiffness in body flap. Failure observed during low frequency acoustic certification tests at JSC. KSC performed modal tests of body flap. Body flap will be removed to determine cause of excessive noise during modal tests
STS-28-25	Network signal processor frame synchronization errors	IPR-32RV-0020	Network signal processor frame synchronization errors were noted during prelaunch operations at KSC. Also seen on first pass at Bermuda and Indian Ocean. Ground problem previously suspected. MILA tape playback noisy
STS-28-26	Orbiter structure heat damage	Postflight inspection PV-6-136987 PR-STR-2-9-2301	Orbiter structure shows evidence of high heat input. JSC thermal subsystem manager along with KSC and Rockwell-Downey subsystem engineers have reviewed the evidence and agree that no burn through or over-heating occurred. CLOSED
STS-28-27	Crew reported loud thump/thud at first OPS-1 transition	Prelaunch	Crew reported loud thump/thud at the exact time of the first OPS-1 transition. Crew stated that whole vehicle shook. Time is coincident with aerosurface movement to null position from drooped position. Data revealed no flight control or hydraulic anomalies
STS-28-28	SSME 1 GH2 flow control valve showed sluggish response	Ascent	SSME 1 GH2 flow control valve indicated sluggish response during the first 3 minutes of ascent. The valve would not fully stroke nor respond when commanded during the throttle bucket. All flow control valves tested and removed. Valve 1 stuck during signature test
STS-28-29	GOX pressure manifold slow to pressurize	Entry	Rate of rise in pressurizing manifold during entry was slow. JSC will use data from OMI checkout to evaluate problem

TABLE II.- PROBLEM TRACKING SUMMARY

Number	Title	Reference	Comments
STS-28-30	Early transition during entry	Mach 20 to Mach 10 IM28RF31	Early transition during entry from laminar to turbulent flow was observed. Unexpected RCS and control surface activity was observed during roll reversal. TPS tile gap fillers observed extending from Orbiter mold line after landing. Protruding objects would cause early transition. FCS responded in nominal fashion to induce side-slip offset. Early boundary layer transition resulting from protruding gap fillers is not a flight safety issue. Turnaround impact date this condition. No RCS redline concerns.
STS-28-31	Loose foam on ET liquid oxygen umbilical (GFE)	ET separation	The Orbiter/ET well separation camera shows TPS along the entire forward portion of the liquid oxygen umbilical was displaced. The displaced TPS was 18 inches wide by 8 inches long by 2 inches deep. The TPS was loosely attached by the fire barrier coating. The foam is from that portion of the umbilical that is Government furnished equipment to the ET Project.

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